

## Entangling the Social:

Comments on Alexander Wendt, *Quantum Mind and Social Science*

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Alexander Wendt takes a provocative step in *Quantum Mind and Social Science: Unifying Physical and Social Ontology* (Wendt 2015) by proposing that quantum mechanics plays a role in all levels of the human and social world (as well as all life). And he doesn't mean in the trivial sense that all of nature is constituted by quantum-mechanical micro-realities (or unrealities). Instead, he means that we need to treat human beings and social structures as quantum-mechanical wave functions. He wants to see whether some of the peculiarities of social (and individual) phenomena might be explained on the hypothesis that mental phenomena are deeply and actively quantum phenomena. This is a very large pill to swallow, since much considered judgment across the sciences concurs that the macroscopic world -- billiard balls, viruses, neurons -- are on a physical and temporal scale where quantum effects have undergone “decoherence” and behave as strictly classical entities.

Wendt's work rests upon a small but active body of scholarship in physics, the neurosciences, and philosophy on the topics of “quantum consciousness” and “quantum biology”. This line of thought took its origin in Roger Penrose's book, *The Emperor's New Mind: Concerning*

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*Computers, Minds, and the Laws of Physics* (1989). So what is quantum mind, and how could a system of a hundred billion neurons have coherent quantum properties?

### *Wendt's view*

Wendt suggests that an emerging field of research on consciousness, advanced by Giuseppe Vitiello, John Eccles, Roger Penrose, Henry Stapp, and others, may have important implications for our understanding of the social world as well. This is the field of “quantum neuropsychology” -- a body of theory that maintains that puzzles surrounding the mind-body problem may be resolved by examining the workings of quantum behavior in the central nervous system.

The guiding problem in this case is the relation between the mental and the physical. Like all physicalists, I work on the assumption that mental phenomena are embodied in the physical infrastructure of the central nervous system, and that the central nervous system works according to familiar principles of electrochemistry. Thought and consciousness are somehow the “emergent” result of the workings of the complex physical structure of the brain (in a safe and bounded sense of emergence). The novel approach is the idea that somehow quantum physics may play a strikingly different role in this topic than ever had been imagined. Theorists in the field of quantum consciousness speculate that perhaps the peculiar characteristics of quantum events at the sub-atomic level (e.g. quantum randomness, complementary, superposition, entanglement) are close enough to the action of neural networks that they serve to give a neural structure radically different properties from those expected by a classical-physics view of the brain. (This idea isn't precisely new; when I was an undergraduate in the 1960s it was sometimes speculated that freedom of the will was possible because of the indeterminacy created by

quantum physics. But this wasn't a very compelling idea either then or now.)

Wendt presents a complicated and nuanced story, extending from the neuron to the meaning of language to the reality of the state. But the key ideas are these. Human beings (and all other living things) are walking wave functions: “I argue that human beings and therefore social life exhibit quantum coherence - in effect, that we are walking wave functions. I intend the argument not as an analogy or metaphor, but as a realist claim about what people really are” (3). The brain sustains coherent quantum states, and key features of the mind are explained by these states (experience, decision, memory). The brain is a quantum computer. Decision-making conforms to the logic of quantum probability rather than classical probability. Features of consciousness are inherent in everything in the world, from electrons to broccoli to human brains (panpsychism) (5). The quantum concept of “entanglement” applies to objects at every scale (208-209), including human individual people. Meanings and social structures depend upon the entanglement of conscious individuals, and themselves represent a quantum wave function.

In my view the crucial claim here is the quantum interpretation of the brain and consciousness that Wendt (97) advocates. He wants us to consider that the operations of the brain -- the input-output relations and the intervening mechanisms -- are not “classical” but rather quantum-mechanical. And this is a very, very strong claim. It is vastly stronger than the idea that neurons may be affected by quantum-level events (subject to active research by people interested in how microtubules work within neurons). But Wendt would not be satisfied with the idea that “neurons are quantum machines”; he wants to make the vastly stronger argument that “brains are quantum computers”. And even stronger than that -- he wants to claim that the brain itself is a wave

function, which implies that we cannot understand its working by understanding the workings of its (quantum) components. (I don't think that computer engineers who are designing real

quantum computers believe that the device itself is a wave function; only that the components (qubits) behave according to quantum mathematics.) Here is his brain-holism:

*Quantum brain theory hypothesizes that quantum processes at the elementary level are amplified and kept in superposition at the level of the organism, and then, through downward causation constrain what is going on deep within the brain. (95)*

So the brain as a whole is in superposition, and only resolves with perception or will as a whole in an event of the collapse of its wave function. He sometimes refers to “a decoherence-free subspace of the brain within which quantum computational processes are performed” (95), which implies that the brain as a whole is perhaps a classical thing encompassing “quantum sub-regions”. But whether it is the whole brain (implied by “walking wave function”) or a relatively voluminous sub-region, the conjurer's move occurs here: extending known though exotic properties of very special isolated systems of micro-entities (a handful of electrons, photons, or atoms) to a description of macro-sized entities maintaining those same exotic properties.

### *Philosophy of mind*

Much of Wendt's argument depends on his treatment of unresolved controversies in traditional philosophy of mind, including the nature of consciousness and the possibility of freedom of the will. Experts refer to the problem of consciousness as the “hard problem” in the philosophy of mind. We might also call this the discontinuity problem: the unavoidable necessity of a radical break between a non-conscious substrate and a conscious superstrate. How is it possible for an amalgamation of inherently non-conscious things (neurons, transistors, routines in an AI

software package) to create an ensemble that possesses consciousness? The solution that Wendt favors is “panpsychism” – the idea that features of consciousness extend across the whole range of reality, from electron to neuron to brain to person. (And perhaps to social structures as well!)



Panpsychism strikes me as an extravagant and unhelpful theoretical approach, however. Why should we attempt to analyze “Robert is planning to embarrass the prime minister” into a vast ensemble of psychic bits associated with the sub-atomic particles of his body? How does it even make sense to imagine a “sub-atomic bit of consciousness”? And how does the postulation of sub-atomic characteristics of consciousness give us any advantage in understanding ordinary human consciousness, deliberation, and intentionality?

Further, we do not need to solve the problems of consciousness or freedom of the will in order to do social science. These are interesting problems, to be sure, how freedom, consciousness, and intentionality can emerge from the wetware of the brain. But it is not necessary to solve this problem before we proceed with social science. Instead, we can begin with phenomenological truisms: we are conscious, we are intentional, and we are (in a variety of conditioned senses) free. How the organism achieves these higher-level capabilities is intriguing to study; but we don't have to premise our sociological theories on any particular answer to this question.

So the position I want to take here is that we don't have to solve the mysteries of quantum mechanics in order to understand social processes and social causation. We can bracket the metaphysics of the quantum world -- much as the Copenhagen interpretation sought to do -- without abandoning the goal of providing a good explanation of aspects of the social world and social actors. Wendt doesn't like this approach (75); but it seems perfectly reasonable to suspend hard questions in the philosophy of mind in order to get on with research about social actors and institutions.

Another cornerstone of Wendt's argument is a set of findings in decision theory. Wendt is impressed with the credibility and predictive niceness of "quantum decision theory". The foundational text in this field is Busemeyer and Bruza, *Quantum Models of Cognition and Decision* (Busemeyer and Bruza 2012). Busemeyer and Bruza argue here, and elsewhere, that the mathematics and concepts of quantum mechanics in physics have seemingly relevant application to the field of cognition and judgment as well. For example, the idea of "wave function collapse" appears to have analogy with the resolution of uncertainty onto decision by a human cognitive agent. Busemeyer and Bruza offer six fundamental analogies between quantum mechanics and cognition:

- ☐ judgments are based on indefinite states
- ☐ judgments create rather than record
- ☐ judgments disturb each other, introducing uncertainty
- ☐ judgments do not always obey classic logic
- ☐ judgments do not obey the principles of unicity
- ☐ cognitive phenomena may not be decomposable

For these and related reasons Busemeyer and Bruza argue that the mathematics, logic, and concepts of quantum mechanics may allow us to reach better traction with respect to the processes of belief acquisition and judgment that constitute human cognition. So far so good -- there may be a mathematical homology between quantum states in the micro-physical world and

states of knowledge acquisition at the level of acquisition.

However, Busemeyer and Bruza are entirely explicit in saying that they regard this solely as a formal analogy -- not a hypothesis about the real underlying structure of human thought. They

explicitly deny that they find evidence to support the idea that consciousness is a quantum phenomenon at the sub-molecular level. They are “agnostic toward the so-called 'quantum mind' hypothesis” (xii). Their use of the mathematics of quantum mechanics is formal rather than substantive -- more akin to using the mathematics of fluid dynamics to represent flow through a social network than arriving at a theory of the real constitution of a domain as a basis for explaining its characteristics.

*This book is not about quantum physics per se, but instead it explores the application of the probabilistic dynamic system created by quantum theory to a new domain - the field of cognition and decision making. (1)*

So the application is heuristic rather than realistic:

*We motivate the use of quantum models as innovative abstractions of existing problems. That is all. These abstractions have the character of idealizations in the sense there is no claim as to the validity of the idealization “on the ground.”(xii)*

*Instead [our theory] turns to quantum theory as a fresh conceptual framework for explaining empirical puzzles, as well as a rich new source of alternative formal tools. To convey the idea that researchers in this area are not doing quantum mechanics, various modifiers have been proposed to describe this work, such as quantum-like models of cognition, cognitive models based on quantum structure, or generalized quantum models. (xi)*

So it seems to this reader that the findings of quantum decision theory are not a source of compelling evidence for the truth of the major idea – that the brain is a quantum wave function.

### *Biological quantum effects*

Is it possible in theory for cognitive processes, or neuroanatomical functioning, to be affected by

events at the quantum level? Are there known quantum effects within biological systems? Here is one interesting case that is currently being explored by biologists: an explanation of the ability of birds to navigate by the earth's magnetic field in terms of the chemistry of entangled electrons.

Quantum entanglement is defined as a relation between two or more micro-particles (photons, electrons, atoms) in which the quantum state of one is entangled with the quantum state of the other. When observation of the first part of the pair brings about alteration of the quantum state in that particle, quantum theory entails that the state of the second particle will change as well.

It has been hypothesized that the ability of birds to navigate by reference to the earth's magnetic field may be explained by quantum effects of electrons in molecules (cryptochromes) in the bird's retina. Thorsten Ritz is a leader in this area of research. In "Magnetic Compass of Birds Is Based on a Molecule with Optimal Directional Sensitivity" (Ritz et al. 2009) he and his co-authors describes the hypothesis in these terms:

*The radical-pair model (7,8) assumes that these properties of the avian magnetic compass'light-dependence and insensitivity to polarity'directly reflect characteristics of the primary processes of magnetoreception. It postulates a crucial role for specialized photopigments in the retina. A light-induced electron-transfer reaction creates a spin-correlated radical pair with singlet and triplet states. (3451)*

Markus Tiersch and Hans Briegel address these findings in "Decoherence in the chemical compass: the role of decoherence for avian magnetoreception" (Tiersch and Briegel 2012). They describe the hypothetical mechanism of paired-electron chemistry as a mechanism in birds for detecting magnetic fields:

*Certain birds, including the European robin, have the remarkable ability to orient themselves, during migration, with the help of the Earth's magnetic field [3-6]. Responsible for this 'magnetic sense' of the robin, according to one of the main hypotheses, seems to be a molecular process called the radical pair mechanism [7,8] (also, see [9,10] for reviews that include the historical development and the detailed facts leading to the hypothesis). It involves a photo-induced spatial separation of two*

*electrons, whose spins interact with the Earth's magnetic field until they recombine and give rise to chemical products depending on their spin state upon recombination, and thereby to a different neural signal. The spin, as a genuine quantum mechanical degree of freedom, thereby controls in a non-trivial way a chemical reaction that gives rise to a macroscopic signal on the retina of the robin, which in turn influences the behaviour of the bird. When inspected from the viewpoint of decoherence, it is an intriguing interplay*

*of the coherence (and entanglement) of the initial electron state and the environmentally induced decoherence in the radical pair mechanism that plays an essential role for the working of the magnetic compass. (4518)*

So the hypothesis is that birds (and possibly other organisms) have evolved ways of exploiting “spin chemistry” to gain a signal from the presence of a magnetic field.

Tiersch and Briegel go through the quantum-mathematical details on how this process might work in the case of molecules that might be found in birds' retinas. Here is the conclusion drawn by Tiersch and Briegel:

*It seems that the radical pair mechanism provides an instructive example of how the behaviour of macroscopic entities, like the European robin, may indeed remain connected, in an intriguing way, to quantum processes on the molecular level. (4538)*

This line of thought is still unconfirmed, as both Ritz and Tiersch and Briegel are careful to emphasize. If confirmed, it would provide an affirmative answer to the question posed above -- are there biological effects of quantum-mechanical events? But even if confirmed, it doesn't seem like an enormously surprising result. It traces out a chemical reaction which proceeds differently depending on whether entangled electrons in molecules stimulated by a photon have been influenced by a magnetic field; this gives the biological system a signal about the presence of a magnetic field that does in fact depend on the quantum states of a pair of electrons.

Entanglement is now well confirmed, so this line of thought isn't particularly radical. But this is entirely less weird than the idea that quantum particles are “conscious”, or that consciousness extends all the way down to the quantum level (quantum interactive dualism, as Henry Stapp calls it (Stapp 2005)). And it is nowhere nearly as perplexing as the claim that “making up one's



mind” is a form of a collapsing quantum state represented by a part of the brain.

So this finding, even if validated, does not lend support to Wendt's larger and more ambitious claims: that the brain itself is a quantum computer or a quantum wave function. And without that premise, the rest of the structure about will, experience, meaning, and social entanglement collapse.

### *Experimental results*

Some of the implications of the ideas about quantum involvement in the brain have been explored by experimental physicists and neuroscientists. The key issue is the difference in scale between the sub-atomic level and macro-scale entities and events. It is generally believed that quantum effects disappear at higher scales and temperatures (decoherence). It would be peculiar to speculate that we need to invoke the mathematics and theories of quantum physics to explain billiards. It is pretty well agreed by physicists that quantum mechanics reduces to Newtonian physics at this scale. Even though the component pieces of a billiard ball are quantum entities with peculiar properties, as an ensemble of  $10^{25}$  of particles in Brownian motion affecting all the particles, the behavior of the ball is safely classical. The peculiarities of the quantum level wash out for systems with multiple Avogadro's numbers of particles through the reliable workings of statistical mechanics. And the intuitions of most people comfortable with physics would lead them to assume that neurons are subject to the same independence; the scale of activity of a neuron (both spatial and temporal) is orders of magnitude too large to reflect quantum effects.

Max Tegmark (Tegmark 1999) reported a set of fundamental physical computations intended to

demonstrate that quantum coherence at the cellular scale was all but impossible. Tegmark's analysis focuses on the speculations offered by Penrose (Penrose 1989) and others on the possible quantum behavior of “microtubules.” Tegmark purports to demonstrate that the time

and space scales of quantum effects are too short by orders of magnitude to account for the neural mechanisms that can be observed. Here are Tegmark's conclusions as expressed in his abstract:

*Based on a calculation of neural decoherence rates, we argue that the degrees of freedom of the human brain that relate to cognitive processes should be thought of as a classical rather than quantum system, i.e., that there is nothing fundamentally wrong with the current classical approach to neural network simulations. We find that the decoherence time scales ( $\sim 10^{-13}$ – $10^{-20}$  s) are typically much shorter than the relevant dynamical time scales ( $\sim 10^{-3}$ – $10^{-1}$  s), both for regular neuron firing and for kinklike polarization excitations in microtubules. This conclusion disagrees with suggestions by Penrose and others that the brain acts as a quantum computer, and that quantum coherence is related to consciousness in a fundamental way. (1)*

So the “brain as quantum computer” or “brain as wave function” theory is very implausible given current knowledge. But if this view of the brain and thought cannot be made more credible than it currently is -- both empirically and theoretically -- then Wendt's whole system falls apart: entangled individuals involved in structures and meanings, life as a quantum-vital state, and panpsychism all have no inherent credibility by themselves. (I should note that Wendt considers and rejects these arguments; 103ff. A rebuttal by Hagan, Hameroff, and Tuszynski 2002 also attempts to undermine the significance of Tegmark's calculations. Hameroff is one of the originators of the microtubules idea.)

Another relevant but modest line of experimentation currently underway has to do with probing whether biological objects on a scale of viruses can be shown experimentally to display quantum characteristics like superposition. Romero-Isart and colleagues (Romero-Isart et al. 2010)

describe an experimental setup that uses well developed technologies in quantum optomechanical research to trap a virus object; reduce it to its ground state; stimulate it with a photon; and measure to determine whether superposition has occurred. The experimental setup is carefully designed to exclude sources of decoherence (heat primarily). The physics of the setup

also impose a limit on the size of the object to be tested; size must be less than the wavelength of the photons to which it is exposed. This experiment had not been performed at the time of publication, but it is instructive to see how exacting the requirements are for a micro-sized object to plausibly maintain quantum coherence.

This proposal is interesting in the context of Wendt's ideas because it sets a "realism" limit on the idea that the brain itself is a quantum wave function. Romero-Isart and colleagues offer an experimental setup for answering the question, "Can composite living things possess quantum characteristics as wholes?". But the scale of the object of their investigation – a virus – and the physics and experimental obstacles are substantial enough, to make it highly implausible that extended networks of neurons including billions of cells could possess room-temperature quantum coherence.

Hans Briegel and Sandu Popescu provide a theoretical analysis of the possibility of entanglement within cellular-scale biological systems (Briegel and Popescu 2009, Briegel and Popescu 2013). They argue that general considerations linking thermal noise to rapid decoherence may work differently in some biological environments, making the possibility of persistent entanglement more feasible. One of their lines of thought involves "intra-molecular refrigeration"—essentially a hypothetical process through which heat is reduced within a molecule, thus reducing the speed of decoherence of quantum states. However, as they make clear in both articles cited here, the effects they describe are purely theoretical without experimental evidence at this point. Moreover, they specifically reject the idea that is Wendt's central premise: the notion that macro-

assemblages of cells might maintain coherence.

*We would also like to mention that we are by no means suggesting the possibility of entanglement at very large scale - such as super-positions of brain states leading*

*possibly to quantum computation in the brain, etc.. This seems to us virtually impossible and here we fully agree with the sceptical view expressed in Ref. [4] (see also [13]). What we are interested in is persistent and controllable entanglement with presumably biological function, at the level of bio-chemical processes. (2009 : 6)*

So Briegel and Popescu too cast a physicist's doubt on the key premise: that brains possess persistent coherent quantum properties; and that we are walking wave functions. This is indeed the position taken by two eminent quantum physicists, H. M. Wiseman and J. Eisert (Wiseman and Eisert 2008):

*This effect of decoherence is one of the main concerns in research on quantum computation [31], where ingenious ways are being explored of shielding engineered and strongly cooled quantum systems from their respective environments. In fact, decoherence is the key challenge in the realization of a full-scale quantum computer. In large scale biological systems, like the brain, decoherence renders large scale coherence (as necessary for quantum computation) very implausible. Even the most optimistic researchers cannot deny the fact that the brain is a warm and wet environment. This is in contrast to the high-vacuum environment used in the beautiful experiments on spatial superpositions of organic molecules from Markus Arndt's and Anton Zeilinger's group in Vienna [23]. In the realistic biological setting, even the most conservative upper bounds to realistic decoherence times are dauntingly small [43].*

This is essentially the conclusion reached by Tegmark in 1999.

### *Assessment*

There are many eye-widening claims here -- and yet Wendt is clear enough and well-versed enough in relevant areas of research in neuroscience and philosophy of mind to give his case some credibility. He lays out his case with calm good humor and rational care. Wendt relies heavily on the fact that there are difficult unresolved problems in the philosophy of mind and the philosophy of physics (the nature of consciousness, freedom of the will, the interpretation of the



quantum wave function). This gives impetus to his call for a fresh way of approaching the whole field -- as suggested by historians of science like Kuhn and Lakatos. However, failing to reach an

answer to the question, “How is freedom of the will possible?”, does not warrant us to jump to highly questionable assumptions about neurophysiology.

And really -- this is just not a plausible theory in my assessment. There is a risk in this field to succumb to the temptation towards unbounded speculation: “Maybe if X's could influence Y's, then we could explain Z” without any knowledge of how X, Y, and Z are related through causal pathways. And the field seems sometimes to be prey to this impulse: “If quantum events were partially mental, then perhaps mental events could influence quantum states (and from there influence macro-scale effects).” I am not ready to accept the ideas of quantum brains, quantum meanings, or quantum societies. The idea of entanglement has a specific meaning when it comes to electrons and photons; but metaphorical extension of the idea to pairs or groups of human individuals seems like a stretch. I'm not persuaded that we are “walking wave functions” or that entanglement accounts for the workings of social institutions. The ideas of structures and meanings as entangled wave functions (individuals) strike me as entirely speculative, depending on granting the possibility that the brain itself is a single extended wave function. And this is a lot to grant.

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